Slow Shape-Recovery of Randomly Disordered Nematic Elastomers

Urayama, Kenji; Honda, Seiji; Takigawa, Toshikazu

Slow Shape-Recovery of Randomly Disordered Nematic Elastomers

Dept. of Mater. Chem., Kyoto Univ. Kenji Urayama,[1] Seiji Honda, Toshikazu Takigawa

液晶ドメインがランダム配向したポリドメイン構造をもつ液晶エラストマーのひずみ回復挙動を調べた．ひずみ回復は 10^2 秒以上の長い時間を要し，その特性時間は架橋を行った相の種類（等方相もしくはネマチック相）によって変化した．また，液晶相転移温度近傍で特性時間は急激に増加した．

Introduction

"Monodomain" nematic elastomers with global director exhibit a macroscopic deformation coupled with director orientation in fast response to the switch-on and off of electric fields. The response time is in the order of 10^{-3} s.[1] In contrast, "polydomain" nematic elastomers with local order but without global director show a slow shape recovery in the order of 10^4 s after the removal of applied electric fields.[2] This markedly slow shape-recovery process is expected to reflect the process from the oriented polydomain texture to the initial one, but the details still remain to be characterized.

There exist the two different routes to prepare the polydomain nematic elastomers. One is to crosslink the mesogenic monomers in the polydomain nematic phase. The other is to crosslink the mesogens in the isotropic phase and to cool the resulting networks below the transition temperature. In present study, we compare the effect of the mesogen alignment in the crosslinking stage on the equilibrium and dynamic properties of polydomain nematic elastomers. In addition, we examine the temperature effect on the shape recovery behavior, in particular, in the vicinity of the transition temperature.

Experiments

The details of the sample preparation are described in ref 2. The crosslinking of the mesogenic monomers was carried out at 45 °C (polydomain nematic phase) and 90 °C (isotropic phase). The resulting networks are designated as N-GEL and I-GEL, respectively. The networks were allowed to swell fully in a low molecular mass liquid

[1] E-mail: urayama@rheogate.polym.kyoto-u.ac.jp

crystal. The shape recovery after removing the applied electric fields was observed by optical microscopy.

Results and Discussion

The inset of Fig. 1 shows the equilibrium characteristics of N-GEL and I-GEL. No noticeable difference is observed in the degree of swelling and the transition temperatures in the dry and swollen states. In contrast to the equilibrium properties, the dynamics of the shape recovery is significantly influenced by the mesogen alignment in the crosslinking stage. The I-GEL exhibits a much slower shape recovery than the N-GEL. The same trend was observed for the samples with different crosslinking densities. The characteristic time (τ) regarding the shape recovery in the I-GEL is about 5 ~ 10 times larger than that in the N-GEL.

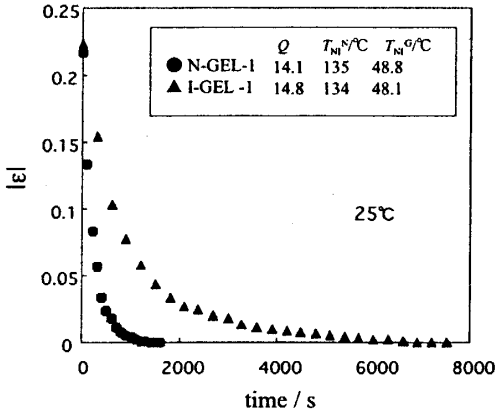

Fig.1 Shape recovery processes and equilibrium properties of N-GEL and I-GEL. The inset shows the equilibrium properties of the samples.

Figure 2 depicts the temperature dependence of τ for the I-GEL. In the vicinity of the transition temperature (T_{NI}^{G}), τ steeply increases. The similar behavior is also observed in the N-GEL. The critical exponent [x; $\tau \sim (T_{NI}^{G} - T)^{-x}$] was estimated to be ca. 0.2 for both I-GEL and N-GEL.

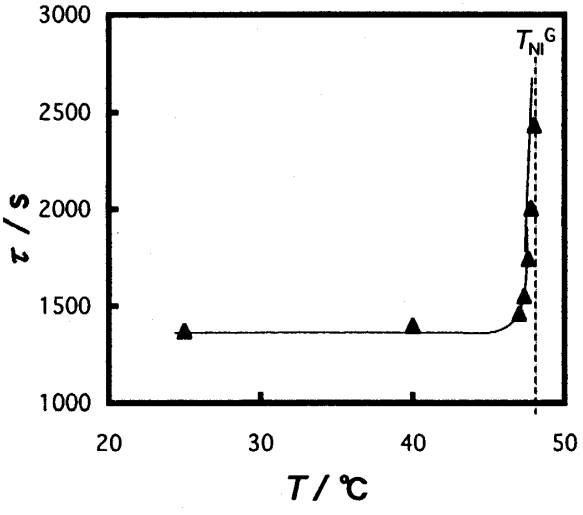

Fig.2 Temperature dependence of τ for I-GEL.

References

1) K. Urayama, S. Honda, T. Takigawa, Macromolecules, **39**(2006), 1943.

2) K. Urayama, H. Kondo, Y. O. Arai, T. Takigawa, Phys. Rev. E, **71**(2005), 051713.